Sept. 13, 1960 C. W. ANDERSEN 2,952,179

ELECTRONIC PIANO

Filed July 21, 1954 2 Sheets-Sheet 1

Fig. 1.

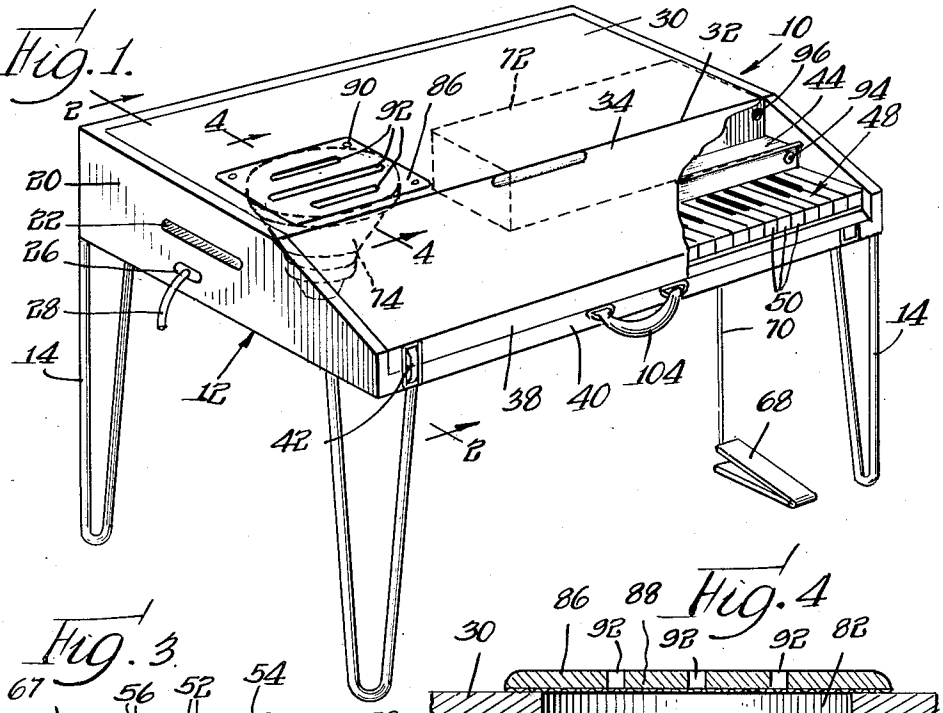


Fig. 4

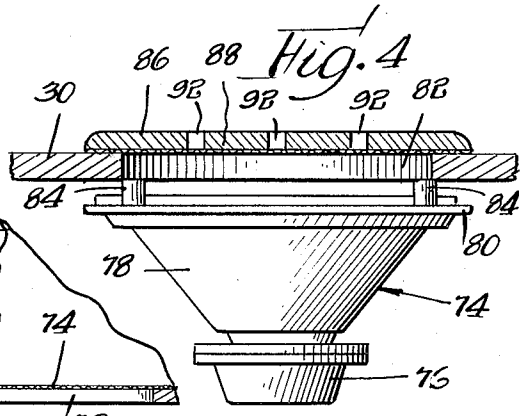
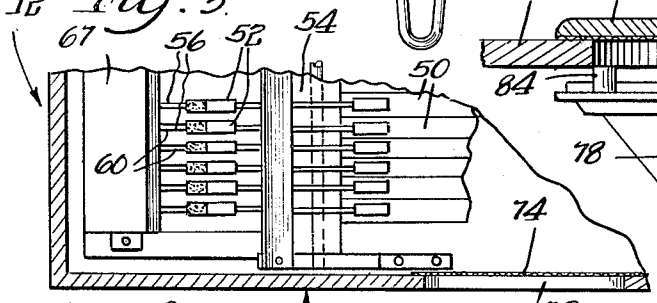


Fig. 3



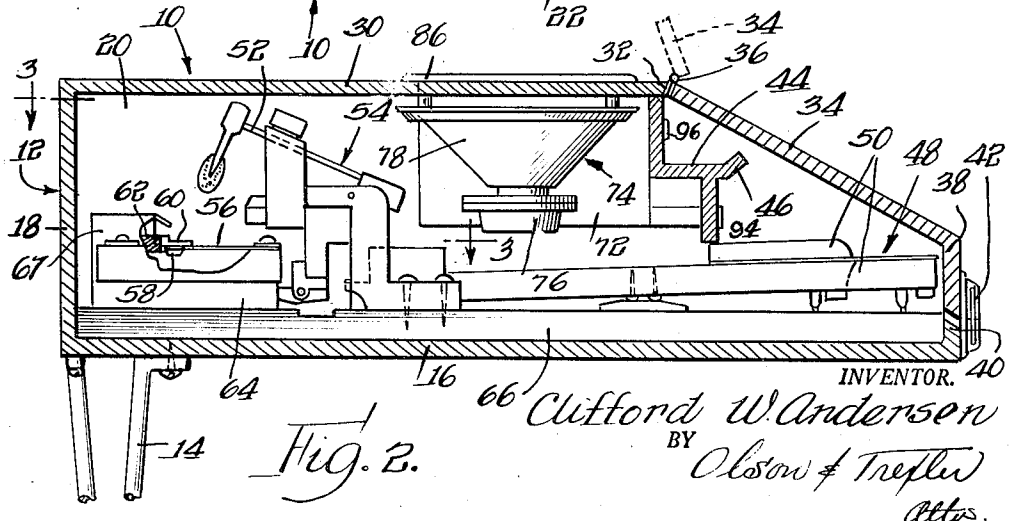


Fig. 2.

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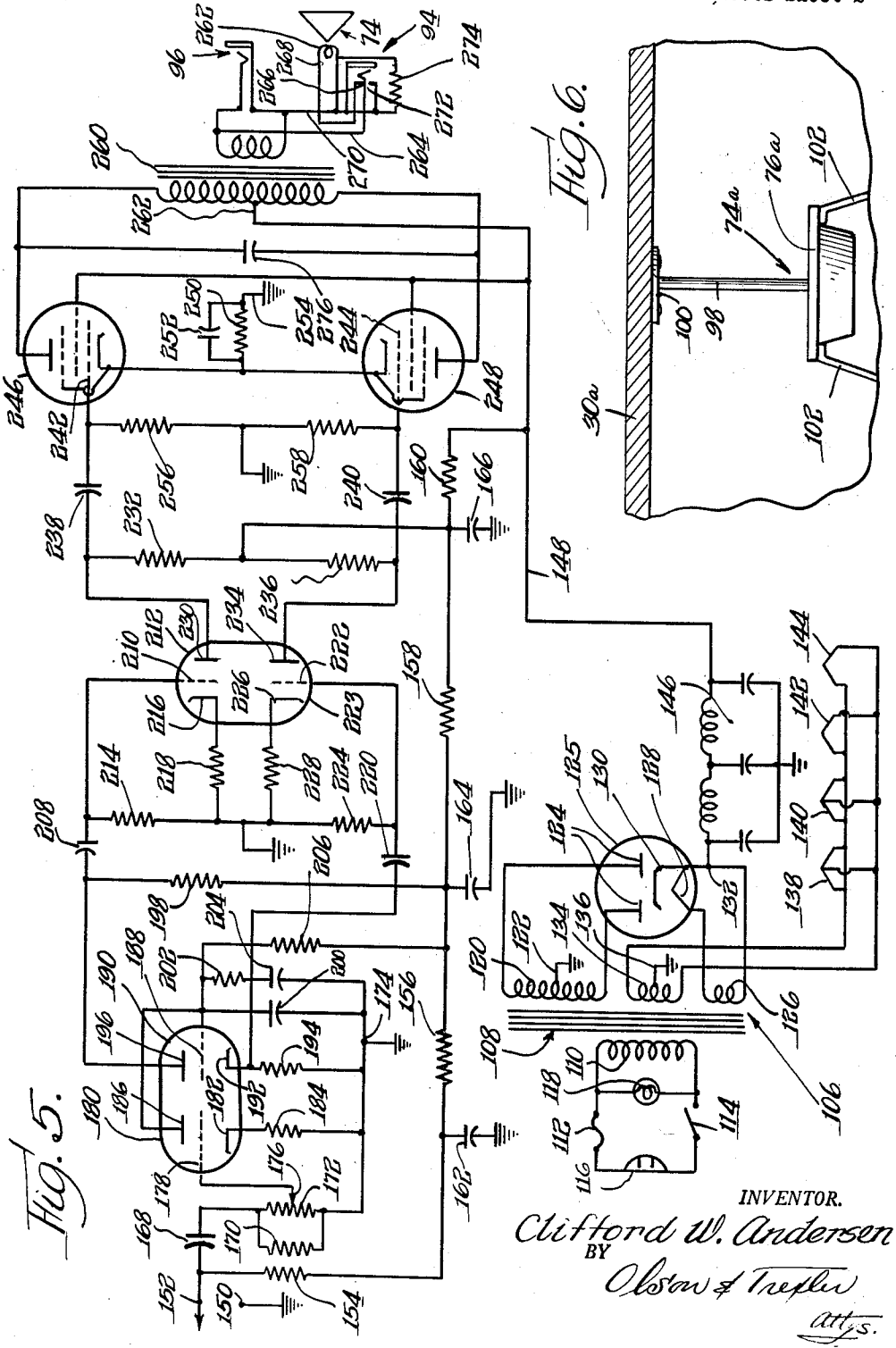


Fig. 5.

Fig. 6.

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ELECTRONIC PIANO

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4 Claims. (Cl. 84—1.24)

This invention is concerned generally with musical instruments, and more particularly with a portable electronic piano.

Pianos and related instruments for a great number of years have utilized tensioned strings as sound generators. In the case of pianos the strings have been actuated percussively by striking them with hammers whereas in other instruments the strings have been plucked.

In order to obtain bass notes with tensioned strings in a piano, the strings must be quite long and heavy. This requires a substantial length in the direction of the strings running from a minimum on the order of four feet for the smallest pianos to a maximum on the order of 10 feet or more in grand pianos. In addition to this, the large number of strings and the tension on each one results in a total string tension or force on the order of several tons. Accordingly, strong and massive frames have been necessary to resist this force. Consequently, the smallest pianos have weighed several hundred pounds while the grand pianos have been on the order of ¾ of a ton or more.

The large size and weight of conventional pianos has rendered them more-or-less stationary in nature. It is true that they can be rolled on casters from one location to another on the same floor, but to move a piano from one floor level to another has been practical only in extreme cases. Furthermore, in home use the large size and weight of pianos has generally restricted them to use on the first floor and in the largest room, generally the parlor. Thus, when a student has desired to practice the piano, the remainder of the family has been annoyed, or has had to leave the parlor.

It has been proposed to produce an electronic piano for reducing the size and weight heretofore necessary in piano construction. In accordance with such proposals hammers are caused to strike vibratory metallic reeds which are mounted in capacitive relation with suitable pick-up means. The capacity between each reed and associated pick-up means varies in accordance with the vibration of the reed, and an oscillating potential corresponding to the musical tone of the reed is developed. Such potential when suitably electronically amplified and transduced produces a piano-like tone. However, in prior instruments true piano tones have not been attained due to the inherent physical characteristics of the reeds and pick-up means, and due to the electrical characteristics of the amplifiers.

It is an object of this invention to provide an electronic piano having tones substantially indistinguishable from those of a conventional piano and much more lifelike than any heretofore known.

It is an object of this invention to provide an electronic piano wherein both electrical and mechanical characteristics of amplifying and transducing means are utilized to produce true piano-like tones.

More specifically, it an object of this invention to provide an electronic piano having a broad band amplifier for properly amplifying the percussive notes of a piano

and for properly amplifying all of the partials, combined with suitable electrical and mechanical components to limit the frequency output for producing realistic piano tones.

It is another object of this invention to utilize a loudspeaker in a specific arrangement for control of tonal effects in an electronic piano.

Still other objects of this invention include the provision of constructional features and arrangement of parts in an electronic piano to achieve small size and weight, and hence ready portability.

Other and further objects and advantages of the present invention will be apparent from the following description when taken in connection with the accompanying drawings wherein:

Fig. 1 is a perspective view of a piano constructed in accordance with the principles of my invention;

Fig. 2 is a cross-sectional view taken substantially along the line 2—2 in Fig. 1;

Fig. 3 is a horizontal view partially in section taken substantially along the line 3—3 in Fig. 2;

Fig. 4 is a cross-sectional view showing the speaker mounting and taken substantially along the line 4—4 in Fig. 1;

Fig. 5 is a schematic wiring diagram of the amplifier in my piano; and

Fig. 6 is a cross-sectional view somewhat similar to Fig. 4 and showing a modified form of transducer.

Referring first to Figs. 1, 2, and 3 for a general description of the invention, there will be seen an electronic piano generally designated by the numeral 10. The piano includes a case 12 which may be supported on a surface such as a desk or a table, or which may be supported by steel or wrought iron legs 14 of the type currently popular for interior decoration.

The case 12 preferably is made of wood or of plywood and preferably is covered with a plastic or leatherette material. The case comprises a flat bottom 16, a rear wall 18 upstanding therefrom, and a pair of end walls 20 upstanding from the rear walls. The end walls are provided with elongated horizontal slots 22 covered on the inside with grille cloth. These slots serve as finger grips for lifting the piano, and also serve as ports for controlling the back loading of the speaker as hereinafter will be brought out more fully. A suitable connector 26 is provided in one of the end walls 20 for cooperation with an electrical connector on a flexible power line 28 for supplying power to the piano.

The piano case also includes a top 30 parallel to the bottom 16 and terminated short thereof as at 32. A cover or lid 34 is hinged to the edge 32 of the top 30 as at 36, and extends diagonally downward to a depending edge portion 38 cooperable with an upstanding flange 40 on the bottom 16. Toggle fasteners 42 are provided on the edge portion 38 and the flange 40 to hold the cover in closed position. The cover is operable to the dashed line position shown in Fig. 2 and in such position cooperates with a tray 44 therebeneath to form a music rack, the tray having an upturned outer edge 46 to prevent sheet music from sliding from the tray.

A keyboard 48 is disposed beneath the cover or lid 34 with the latter in closed position, and is exposed for playing when the lid is raised. The keyboard comprises a plurality of keys 50 including both the white and black keys of a conventional piano keyboard. The number of keys is determined in accordance with any conventional piano keyboard, and in the illustrative embodiment of the invention there are sixty-one keys. The keys are arranged to pivot the hammers 52 of a plurality of corresponding piano actions 54. Each hammer is positioned to strike a vibratory metallic reed 56, there being one reed for each key of the keyboard, and the reeds varying in size and

weight in accordance with their desired frequencies. The ends of some of the reeds may be provided with weights as indicated at **58** in order to achieve the desired vibratory characteristics and to aid in turning the reeds by simply adding to or removing from the weights. Each reed is arranged to vibrate in a slot **60** in a metal bar **62** forming a pick-up element extending across the piano and insulatedly supported from a frame, the frame being supported on rubber blocks **64** on the base plate or bed **66** lying on top of the bottom **16**. A grounded sheet metal shield **67** overlies the pick-ups to prevent electrical interference. The reeds **56** normally are engaged by dampers (not shown) which are retracted individually when the keys are depressed or which all may be retracted simultaneously by a suitable mechanism actuated by a foot pedal **68** (Fig. 1) detachably connected by means such as a Bowden cable **70** to the remainder of the piano.

An amplifier **72**, the electrical construction of which will be discussed shortly, is supported from the under side of the top **30** of the case **12** adjacent one side thereof and adjacent the forward or terminating edge **32** as will be apparent from the drawings. A loudspeaker **74** likewise is supported from the top **30** adjacent the front edge **32**, and toward the opposite side from the amplifier. The speaker is of conventional construction including a driver unit **76** containing a voice coil and magnet, a speaker cone **78** and a frame **80**. The speaker conveniently is of the elliptical type commonly used in automobile radios and is of rather poor quality, particularly being deficient in bass response whereby partially to eliminate bass tones in order properly to simulate piano tones.

An opening **82** (Fig. 4) is provided in the top **30** of the case and the speaker **74** is mounted below this opening and an alignment therewith, spacers **84** being provided to space the speaker a predetermined distance from the top **30** of the case, thereby further controlling the bass response of the instrument. A speaker cover **86** having grille cloth **88** on the under surface thereof is secured over the opening **82** by any suitable means such as screws **90**, and the speaker cover **86** is provided with elongated, rather narrow slots **92** acting with the space between the speaker and the bottom of the top **30** to control the front loading of the speaker cone **78** to limit the bass response to a predetermined degree. Back loading of the speaker cone is determined at least in part by the slots **22** in the ends of the piano case as has been noted previously.

It further is contemplated that ear phones might be utilized for listening to the piano, and for this purpose two jacks **94** and **96** are provided adjacent the right end of the piano keyboard. The first jack **94** is arranged in circuit with the amplifier and loudspeaker in such a manner that when an ear phone plug is inserted, the speaker will automatically be switched out of the circuit and the sound will be reproduced only by the ear phones. The second jack **96** is arranged for connection with the ear phones in parallel with the speaker so that the piano tones can be heard simultaneously from the speaker and from ear phones plugged into the jack **96**.

It is further contemplated that the speaker **74** in the conventional sense could be eliminated and the piano case itself could be used as a sound radiator. As shown in Fig. 6, top **30***a* of the piano case is imperforate. The loudspeaker is replaced by a sound unit **74***a* including a driver unit **76***a* having a magnet and voice coil. The voice coil is arranged to vibrate a rod **98** secured by a suitable fastener **100** to the under side of the case top **30***a*. The driver unit **76***a* may be supported from beneath by means of suitable bracket **102**. When the voice coil vibrates the rod **98**, the vibrations are transmitted to the case top **30***a* which then acts as a sounding board or tone propagator to render the piano tones audible.

The physical parts of the piano now have been described and it will be evident that the piano is small and compact. Excluding the legs, the piano is substantially less than a foot in height, less than two feet in depth, and about three feet across in a specific illustrative embodiment of the invention. The weight of the illustrative embodiment is on the order of seventy to eighty pounds, and it thus will be seen that the piano is readily portable by means of a handle **104** (Fig. 1) on the upturned front flange **40** of the case.

The amplifier is shown in the schematic diagram in Fig. 5 and includes a power supply indicated generally by the numeral **106**. The power supply includes a transformer **108** having a primary winding **110** connected through a fuse **112** and a switch **114** to an electrical connector **116** cooperable with the connector **26** on the line cord **28**. A pilot light **118** is connected across the primary **110** and is disposed above the keyboard of the piano (not shown) for providing a visual indication as to whether the piano is on or off, the switch **114** being positioned next to the pilot light.

The transformer is provided with a high voltage secondary **120** center tapped at **122** and having the ends connected to the plates **124** of a full wave rectifier tube **125** such as a 5V4G. The transformer also has a low voltage filament winding **126** connected to the filament **128** and likewise to the cathode **130** of the rectifier. A power output connection **132** is provided from the cathode of the rectifier tube.

The transformer further includes a low voltage filament winding **134** center tapped at **136** and connected to the filaments **138**, **140**, **142**, and **144** of the tubes shortly to be described. The power output connection **132** is connected to a suitable filter **146** to provide filtered voltage to a B+ bus line **148**.

The amplifier further is provided with a grounded input connection **150**, and an ungrounded input connection **152**. The grounded input connection is connected in parallel to all of the vibratory reeds **56**, while the ungrounded connection is connected in parallel to the metal bar **62** comprising the pick-up means. The ungrounded connection **152** is connected through a resistor **154** and through suitable decoupling networks comprising resistors **156**, **158**, and **160**, and grounded capacitors **162**, **164**, and **166** to the B+ bus line **148**, thereby applying potential to the pick-up means. The reeds and pick-up means act as an electrical capacitor, and this capacity varies when any one or more reeds vibrate in accordance with the vibrations. This change in capacity with the direct current potential applied to the capacitors through the load resistor **154** results in the generation of electrical oscillations which correspond in wave shape and frequency to the vibrations of the reeds.

The ungrounded input **152**, and hence the electrical oscillations generated by the reeds are connected through an input capacitor **168** to a resistor **170** paralleled by a potentiometer **172**, the parallel combination being grounded as at **174**. A sliding tap **176** on the potentiometer is connected to the control grid **178** of an amplifier tube **180**, conveniently one half of a 12AU7. The cathode **182** of the tube **180** is grounded through a cathode load resistor **184**. The plate **186** is directly connected to the control grid **188** of a phase inverter tube **190**, conveniently the other half of the aforementioned 12AU7 tube.

The cathode **192** of the tube **190** is grounded through a cathode load resistor **194**, and the plate **196** is connected through a plate load resistor **198** equal in value to the cathode load resistor **194** to the B+ bus line **148** through the decoupling filters **158**, **164**, and **160**, **166**. A capacitor **200** is connected from the phase inverter grid **188** to ground, as is a series combination of a resistor **202** and a capacitor **204**. The grid also is connected through a resistor **206** to the B+ bus line through the two decoupling filters just mentioned.

The plate output from the phase inverter tube **190** is connected through a capacitor **208** to the grid **210** of an amplifier tube **212**, conveniently one half of another 12AU7 tube. The grid of this tube is grounded through a

grid resistor 214, and the cathode 216 is grounded through a cathode resistor 218. The cathode output is similarly connected through a capacitor 220 to the grid 222 of a parallel amplifier tube 223, conveniently the other half of the second 12AU7 tube. The grid similarly is grounded through a grid resistor 224, and the cathode 226 is grounded through a resistor 228.

The plate 230 is connected through a plate load resistor 232 and through the decoupling filter 160, 166 to the B+ bus line. The plate 234 of the amplifier tube 223 is similarly connected through a load resistor 236 and the decoupling filter 160, 166 to the B+ bus line.

The plates 230 and 234 are respectively connected through capacitors 238 and 240 to the control grids 242 and 244 of matched power output tubes 246 and 248 which conveniently may be of the 6AQ5 type. The cathodes are connected in parallel to a common cathode biasing circuit comprising a resistor 250 paralleled by a capacitor 252 and grounded at 254. The control grids 242 and 244 are respectively connected through grid biasing resistors 256 and 258 to ground.

The screen grids of the two power output tubes are connected in parallel to the B+ bus line, and the suppressors are connected to their respective cathodes in accordance with conventional practice. The plates are connected to the opposite ends of an output transformer 260 having a center tap 262 connected to the B+ bus line.

The output coil of the output transformer 260 is connected in parallel to the jack 96 and to the voice coil 262 of the loudspeaker 74. The connection to the loudspeaker is made through a wire 264, a pair of contacts 266 in the jack 94, a wire 268, and a wire 270. The jack 94 is arranged so that upon insertion of a plug the contacts 266 will be opened to remove the voice coil 262 from the circuit, and complementary contacts 272 will be closed to connect a resistor 274 in place of the voice coil and in parallel with the ear phones. This resistor is a 7.5 ohm resistor and causes a substantially constant impedance to be presented to the output of the amplifier, it being understood that the very high impedance of ear phones relative to the impedance of the speaker voice coil would otherwise materially change the impedance presented to the output of the amplifier.

The amplifier as just described is capable of a broad band response, being substantially flat from 40 c.p.s. to 20,000 c.p.s A capacitor 276 which in an exemplary embodiment is .02 microfarad is connected across the plates of the power output tubes 244 and 246, thereby materially cutting the treble response. The bass response as noted heretofore is cut by the spacing of the speaker from the case, by the small area of the speaker slots, and by the low quality of the speaker. Thus, both electrical and mechanical features are availed of to render the tonal output similar to that of a piano. The broad band amplifier aside from the output thereof is necessary properly to reproduce all of the partials and properly to reproduce the steep wave fronts produced when any of the reeds is struck by its associated hammer. The necessity of the broad band amplifier will be more apparent when it is considered that a Fourier series corresponding to a steep front wave such as a square wave contains a great many factors multiplied many times in frequency over the fundamental frequency.

The loading of the speaker, and hence the characteristics of the tonal output, further is controlled by the ports in the ends of the case which help to determine the back loading of the speaker cone. The electrical nature of the piano,

and the physical arrangement thereof including the disposition of the various parts all cooperate to make the piano small and light in weight, and hence readily portable.

The specific structure herein shown and described is to be understood as being exemplary only, and is not to be construed as being limitative of the invention. Various changes in structure will doubtless occur to those skilled in the art, and will be understood as forming a part of my invention insofar as they fall within the spirit and scope of the appended claims.

I claim:

1. An electronic piano comprising a substantially completely closed case of generally wide and shallow construction and having an aperture therein, said case having a top and bottom, a plurality of piano actions mounted in said case on the bottom thereof and including a plurality of piano keys opening forwardly of the case and a plurality of hammers respectively operatively connected thereto, a plurality of vibratory reed tone generators mounted in said case and percussively actuated by the hammers of the piano actions, electronic amplifying means within said case for amplifying the electrical oscillations generated by said reeds when vibrating, said amplifying means having an essentially flat frequency response substantially throughout the audio range, a loudspeaker, means for mounting said loudspeaker in said case facing said aperture in said case and spaced from the adjacent portions of the case and providing an air bypass, said loudspeaker being inherently deficient in bass response whereby to limit the bass oscillations as transduced by the loudspeaker, said air bypass further limiting the bass response, a capacitor connected across the output of said amplifying means to limit the high frequency output thereof, and restricted back-loading port means in said case displaced from said speaker.

2. An electronic piano as set forth in claim 1, wherein the aperture is in the top of the case, and wherein the loudspeaker depends from said top and opens up through said aperture.

3. An electronic piano as set forth in claim 1, wherein the case further includes a pair of opposite end walls, wherein the restricted back-loading port means comprises a pair of horizontally elongated slots respectively in said end walls and adapted to act as hand grips for lifting said piano.

4. An electronic piano as set forth in claim 1, wherein the piano actions are mounted on the bottom of said case.

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